U.S. DEPARTMENT OF COMMERCE
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PB-256 630

Westler Lake
LaGrange County, Indiana

Pacific NW Environmental Res. Lab.

Prepared For
National Environmental Res. Ctr.

March 1976

243114

PB 256 630

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

G.P.O. 699-440

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Westler Lake, LaGrange County, Indiana		5. REPORT DATE Prepared March, 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 346
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114		

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C
18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 34 pp.
	20. SECURITY CLASS *(This page)*	22. PRICE 4.00

EPA Form 2220-1 (9-73)

PRICES SUBJECT TO CHANGE

REPORT
ON
WESTLER LAKE
LAGRANGE COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 346

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
MARCH, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

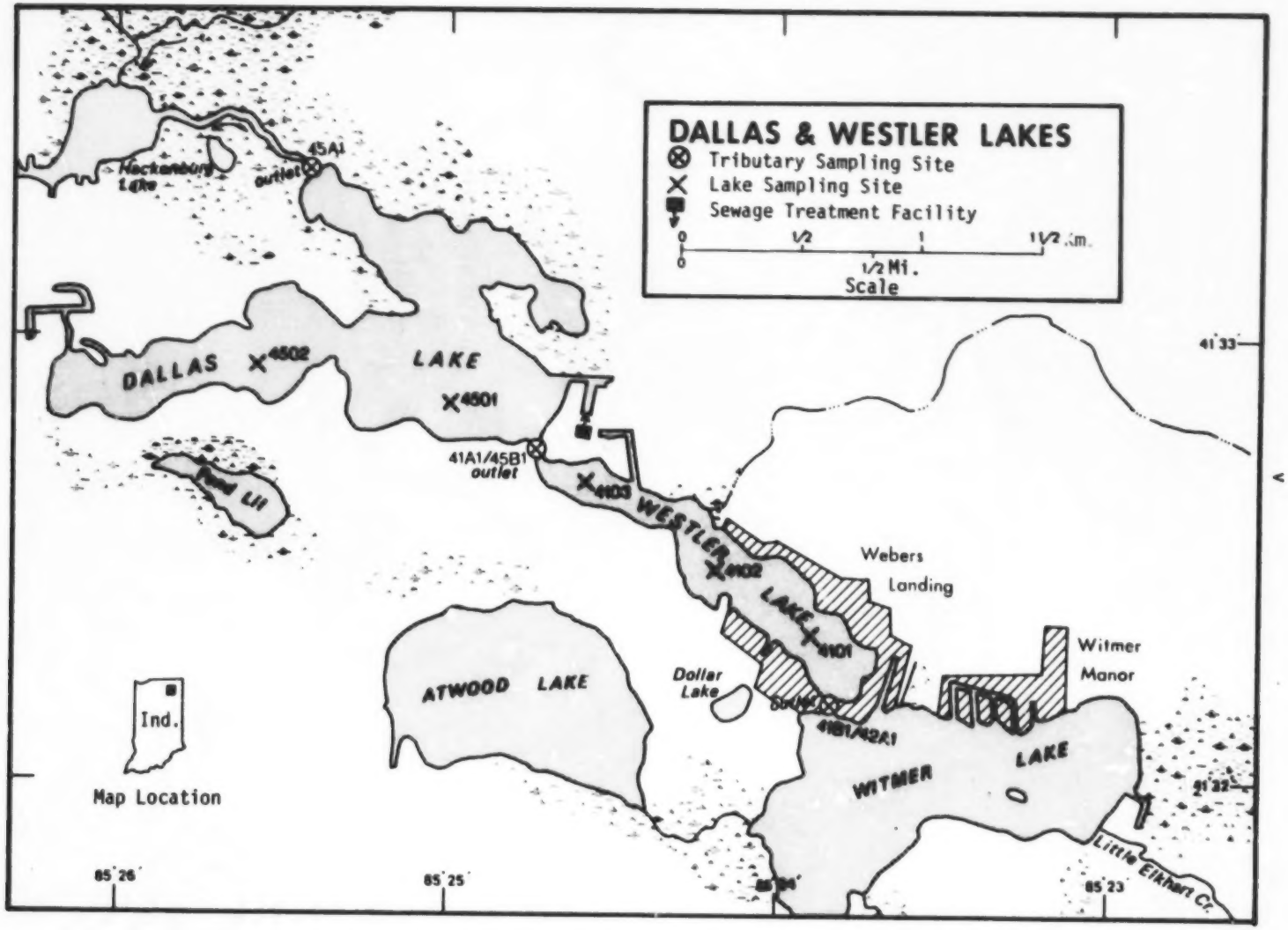
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


DALLAS & WESTLER LAKES
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1/2 1 1 1/2 km.
0 1/2 Mi.
Scale
45A1
Hackenburg Lake
outlet
DALLAS LAKE
4502
4501
41A1/45B1 outlet
Reed Lil
4103
WESTLER LAKE
4102
4101
Webers Landing
Witmer Manor
ATWOOD LAKE
Dollar Lake
41B1/42A1
WITMER LAKE
Little Elkhart Cr.
Ind.
Map Location
41°33'
41°32'
85°26'
85°25'
85°24'
85°23'

WESTLER LAKE

STORET NO. 1841

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Westler Lake is eutrophic. Of the 27 Indiana water bodies sampled in 1973, Westler Lake ranked thirteenth in overall trophic quality using a combination of six parameters*. Twelve lakes had less and two had the same median total phosphorus, 16 had less and one had the same median dissolved phosphorus, 12 had less median inorganic nitrogen, nine had less mean chlorophyll a, and nine had greater mean Secchi disc transparency.

Survey limnologists observed algal blooms and macrophytes in the shallow areas at stations 1 and 2 in August. Hypolimnetic dissolved oxygen was depleted at stations 1 and 2 in August and October and at station 3 in October.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Westler Lake was phosphorus limited at the time the sample was collected (05/03/73). The lake data indicate phosphorus limitation in August as well but nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Westler Lake received a total phosphorus loading over 2½ times that proposed

* See Appendix A.

by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading.

Other than the estimated septic tanks loads, there were no known point sources directly impacting the lake, However, the Village of Wolcottville is an indirect source which impacts Witmer Lake (see map, page v) and contributed 190 kg total phosphorus to that lake during the sampling year.

On the basis of the measured phosphorus retention in Witmer Lake (less than 33% during the sampling year), it is calculated that 90% phosphorus removal at Wolcottville would reduce the total load to Westler Lake by more than 7% and would reduce the loading rate to about 4 $g/m^2/yr$. While this rate is still more than two times Vollenweider's eutrophic rate, it is questionable whether his model is applicable to Westler Lake because of the short mean hydraulic retention time of the lake (27 days); and it is possible that a high degree of phosphorus control at the indirect point source would result in persistent phosphorus limitation (see page 7) and a reduction in the incidence and severity of nuisance algal blooms in Westler Lake. Also, the phosphorus reduction probably would benefit downstream Dallas Lake (see map, page v), since Westler Lake retained less than 12% of the phosphorus load received during the sampling year.

2. Non-point sources--During the sampling year, the non-point phosphorus contributions of the Witmer Lake outlet and the immediate drainage accounted for 98% of the total phosphorus load to Westler Lake.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.36 kilometers^2.
2. Mean depth: 6.1 meters.
3. Maximum depth: 11.6 meters.
4. Volume: 2.184×10^6 m^3.
5. Mean hydraulic retention time: 27 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Witmer Lake outlet	93.5	0.88
Minor tributaries & immediate drainage -	4.0	0.04
Totals	97.5	0.92

2. Outlet -

Dallas Lake inlet	97.9**	0.92

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Westler Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 8.5 meters at station 1, 8.8 meters at station 2, and 8.8 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WESTLER LAKE
STORET CODE 1841

PARAMETER	1ST SAMPLING (5/ 3/73) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/12/73) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	8.7 - 13.3	12.3	13.1	11.6 - 25.2	19.2	21.0	10.2 - 19.5	15.3	16.5
DISS OXY (MG/L)	2.3 - 10.9	8.1	9.6	0.0 - 8.5	3.8	3.0	0.0 - 8.6	2.8	0.9
CNDCTVY (MCROMO)	510. - 535.	518.	520.	398. - 461.	436.	440.	400. - 439.	415.	410.
PH (STAND UNITS)	7.7 - 8.4	8.2	8.3	7.2 - 8.4	7.9	7.9	7.1 - 8.5	7.7	7.6
TOT ALK (MG/L)	200. - 214.	206.	206.	188. - 310.	222.	203.	181. - 318.	221.	193.
TOT P (MG/L)	0.018 - 0.054	0.034	0.033	0.025 - 0.630	0.114	0.037	0.018 - 0.634	0.209	0.048
ORTHO P (MG/L)	0.003 - 0.018	0.006	0.005	0.003 - 0.503	0.077	0.013	0.009 - 0.606	0.181	0.033
NO2+NO3 (MG/L)	0.530 - 0.810	0.777	0.800	0.060 - 0.100	0.081	0.080	0.020 - 0.060	0.034	0.035
AMMONIA (MG/L)	0.060 - 0.620	0.147	0.080	0.080 - 5.450	1.022	0.230	0.060 - 6.490	1.868	0.565
KJEL N (MG/L)	0.800 - 1.480	0.947	0.900	0.900 - 7.400	2.183	1.500	0.900 - 9.000	3.517	1.800
INORG N (MG/L)	0.850 - 1.150	0.924	0.880	0.150 - 5.520	1.103	0.300	0.080 - 6.530	1.902	0.605
TOTAL N (MG/L)	1.600 - 1.930	1.723	1.700	0.970 - 7.470	2.264	1.575	0.920 - 9.040	3.551	1.845
CHLRPYL A (UG/L)	11.9 - 13.3	12.6	12.7	10.1 - 13.6	11.8	11.8	7.4 - 8.7	8.0	8.0
SECCHI (METERS)	1.8 - 2.1	2.0	2.1	1.4 - 1.4	1.4	1.4	1.9 - 2.0	1.9	2.0

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/03/73	1. Fragilaria sp.	2,069
	2. Asterionella sp.	943
	3. Flagellates	318
	4. Aphanizomenon sp.	196
	5. Oscillatoria sp.	147
	Other genera	233
	Total	3,906
08/03/73	1. Oscillatoria sp.	663
	2. Gomphosphaeria sp.	186
	3. Aphanizomenon sp.	176
	4. Flagellates	133
	5. Microcystis sp.	53
	Other genera	35
	Total	1,246
10/12/73	1. Aphanizomenon sp.	715
	2. Oscillatoria sp.	345
	3. Flagellates	222
	4. Fragilaria sp.	99
	5. Anabaena sp.	74
	Other genera	247
	Total	1,702

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/03/73	1	11.9
	2	12.7
	3	13.3
08/03/73	1	10.1
	2	13.6
	3	-
10/12/73	1	8.7
	2	8.0
	3	7.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.960	0.8
0.050 P	0.060	0.960	14.6
0.050 P + 1.0 N	0.060	1.960	14.5
1.0 N	0.010	1.960	2.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Westler Lake was moderate at the time the assay sample was collected. The results also indicate phosphorus limitation at that time. Note that when only nitrogen was added, the yield was not significantly increased over the control yield; but, with the addition of orthophosphorus alone, the yield increased 18-fold.

The lake data also indicate phosphorus limitation in August (the mean inorganic nitrogen/orthophosphorus ratio was 14/1) but nitrogen limitation in October (the mean N/P ratio was 11/1).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

The inlet station of Westler Lake is the outlet station of Witmer Lake** (1842A-1), and the outlet station of Westler Lake is the inlet station of Dallas Lake*** (1845B-1).

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station C-1 of nearby Witmer Lake and multiplying by the ZZ area in km^2.

Note that the estimated septic tank phosphorus loading was reduced by 50% to adjust for the Indiana phosphate detergent ban instituted in January, 1972.

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* See Working Paper No. 175.
** Working Paper No. 349.
*** Working Paper No. 326.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Witmer Lake outlet	1,530	96.8
b. Minor tributaries & immediate drainage (non-point load) -	25	1.6
c. Known municipal STP's - None	-	-
d. Septic tanks* -	20	1.3
e. Known industrial - None	-	-
f. Direct precipitation** -	5	0.3
Total	1,580	100.0

2. Outputs -

Dallas Lake inlet 1,400

3. Net annual P accumulation - 180 kg.

* Estimate based on 140 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Witmer Lake outlet	53,730	94.0
b. Minor tributaries & immediate drainage (non-point load) -	1,525	2.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	1,490	2.6
e. Known industrial - None	-	-
f. Direct precipitation** -	390	0.7
Total	57,135	100.0

2. Outputs -

Dallas Lake inlet	66,625

3. Net annual N loss - 9,490 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Witmer Lake outlet	16	575

* Estimate based on 140 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	4.39	0.50	158.7	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Westler Lake:	
"Dangerous" (eutrophic loading)	1.68
"Permissible" (oligotrophic loading)	0.84

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, unknown and unsampled point sources discharging directly to the lake, underestimation of the nitrogen loads from the ungaged drainage and/or septic tanks, or (probably) insufficient outlet sampling in relation to the short hydraulic retention time of the lake. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's former National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

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Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.058	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.623	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	384.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.980	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.480	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.867	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.002	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.445	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.650	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	580-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MANSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1848	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1885	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1841 WESTLER LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 97.9

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1841A1	97.9	1.21	1.41	1.99	1.87	1.21	0.91	0.56	0.21	0.19	0.21	0.48	0.87	0.92
184181	93.5	1.15	1.35	1.89	1.78	1.16	0.87	0.53	0.20	0.18	0.20	0.46	0.84	0.88
1841ZZ	4.1	0.045	0.059	0.088	0.079	0.051	0.040	0.023	0.006	0.007	0.007	0.020	0.040	0.039

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 97.9
SUM OF SUB-DRAINAGE AREAS = 97.6
TOTAL FLOW IN = 11.07
TOTAL FLOW OUT = 11.12

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1841A1	6	73	1.529	9	2.265				
	7	73	1.648	14	1.076				
	8	73	0.765	12	0.736				
	9	73	0.538	8	0.566				
	10	73	0.481	6	0.481				
	11	73	0.481	9	0.425				
	12	73	0.906	8	0.680				
	1	74	1.529	9	0.906				
	2	74	1.897	9	2.124	23	2.265		
	3	74	2.322	9	2.945	23	2.067		
	4	74	1.671	13	1.897				
	5	74	1.501	11	1.274				
184181	6	73	1.472	9	2.152				
	7	73	0.991	14	1.019				
	8	73	0.736	12	0.708				
	9	73	0.510	8	0.538				
	10	73	0.453	6	0.453				
	11	73	0.453	9	0.396				
	12	73	0.878	8	0.651				
	1	74	1.472	9	0.878				
	2	74	1.812	9	2.039	23	2.152		
	3	74	2.209	9	2.832	23	1.982		
	4	74	1.586	13	1.812				
	5	74	1.444	11	1.218				
1841ZZ	6	73	0.065	9	0.096				
	7	73	0.045	14	0.045				
	8	73	0.034	12	0.031				
	9	73	0.022	8	0.024				
	10	73	0.020	6	0.020				
	11	73	0.020	9	0.018				
	12	73	0.040	8	0.028				
	1	74	0.065	9	0.040				
	2	74	0.079	9	0.091	23	0.096		
	3	74	0.099	9	0.125	23	0.088		
	4	74	0.071	13	0.079				
	5	74	0.065	11	0.054				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184101
41 32 20.0 085 23 48.0 3
WESTLER LAKE
18087 INDIANA

11EPALES 2111202
0033 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	15 35	0000	13.3		72	520	8.30	200	0.060	1.100	0.810	0.003
	15 35	0006	13.3	10.0		510	8.40	212	0.060	0.900	0.800	0.004
	15 35	0015	13.3	9.9		530	8.40	208	0.060	0.900	0.810	0.003
	15 35	0022	13.3	10.9		520	8.30	206	0.060	0.900	0.790	0.005
	15 35	0028	10.0	5.8		520	8.00	210	0.280	1.000	0.790	0.010
73/08/03	14 30	0000	25.2	8.2	57	461	8.40	190	0.090	2.200	0.080	0.013
	14 30	0005	24.9	8.5		457	8.40	188	0.080	1.300	0.090	0.009
	14 30	0010	24.4			450						
	14 30	0012	23.5	5.8		460	8.40	197	0.080	1.400	0.090	0.008
	14 30	0015	17.6	0.0		430	7.60	208	0.380	1.600	0.060	0.021
	14 30	0020	13.8	0.0		398	7.50	220	0.680	2.200	0.100	0.055
	14 30	0025	12.6			402						
	14 30	0028	11.6	0.0		430	7.20	300	5.450	7.400	0.070	0.503
73/10/12	11 15	0000	18.8	8.6	78	400	8.40	183	0.060	1.200	0.020	0.010
	11 15	0015	17.8	3.2		402	7.90	187	0.170	1.100	0.020	0.025
	11 15	0020	15.5	0.0		416	7.50	198	0.860	2.100	0.060	0.044
	11 15	0025	11.3	0.0		418	7.20	280	4.180	5.400	0.020	0.243
	11 15	0028	10.6	0.0		438	7.10	310	6.320	7.900	0.040	0.556

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	15 35	0000	0.029	11.9
	15 35	0006	0.041	
	15 35	0015	0.039	
	15 35	0022	0.037	
	15 35	0028	0.035	
73/08/03	14 30	0000	0.029	10.1
	14 30	0005	0.025	
	14 30	0012	0.027	
	14 30	0015	0.052	
	14 30	0020	0.090	
	14 30	0028	0.630	
73/10/12	11 15	0000	0.018	8.7
	11 15	0015	0.031	
	11 15	0020	0.058	
	11 15	0025	0.319	
	11 15	0028	0.634	

STORET RETRIEVAL DATE 76/03/30

184102
41 32 29.0 085 24 11.0 3
WESTLER LAKE
18087 INDIANA

11EPALES 2111202
0033 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	16 50	0000	13.3		84	510	8.30	208	0.080	0.900	0.810	0.005
	16 50	0006	13.3	10.0		510	8.30	206	0.080	0.800	0.800	0.003
	16 50	0015	13.2	9.9		510	8.30	204	0.060	0.800	0.800	0.003
	16 50	0022	13.0	9.5		510	8.30	208	0.100	0.800	0.810	0.004
	16 50	0029	9.7	4.9		510	8.20	200	0.360	1.000	0.710	0.016
73/08/03	15 15	0000	25.1	8.1	57	456	8.40	193	0.120	1.000	0.080	0.003
	15 15	0005	24.2	8.0		457	8.30	190	0.080	0.980	0.070	0.013
	15 15	0010	24.2			455						
	15 15	0012	23.8	6.6		455	8.20	198	0.090	0.900	0.100	0.010
	15 15	0015	18.5	0.2		430	7.50	224	0.340	1.200	0.060	0.014
	15 15	0020	13.6	0.0		405	7.50	240	1.230	2.000	0.090	0.036
	15 15	0025	12.7			405						
	15 15	0028	12.0	0.0		420	7.30	310	3.650	4.100	0.080	0.240
73/10/12	13 50	0000	19.1	8.6	73	401	8.40	182	0.080	1.400	0.040	0.037
	13 50	0015	17.8	2.6		402	7.80	187	0.200	0.900	0.020	0.026
	13 50	0020	15.0	0.0		416	7.50	202	1.480	2.800	0.060	0.029
	13 50	0028	10.7	0.0		439	7.10	280	6.490	7.700	0.040	0.606

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	16 50	0000	0.028	12.7
	16 50	0006	0.030	
	16 50	0015	0.028	
	16 50	0022	0.029	
	16 50	0029	0.043	
73/08/03	15 15	0000	0.026	13.6
	15 15	0005	0.025	
	15 15	0012	0.026	
	15 15	0015	0.046	
	15 15	0020	0.081	
	15 15	0028	0.313	
73/10/12	13 50	0000	0.038	8.0
	13 50	0015	0.037	
	13 50	0020	0.058	
	13 50	0028	0.630	

STORET RETRIEVAL DATE 76/03/30

184103
41 32 41.0 085 24 35.0 3
WESTLER LAKE
18087 INDIANA

11EPALES 2111202
0033 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	17	15 0000	13.1		84	520	8.30	200	0.070	1.100	0.790	0.005
	17	15 0006	13.1	9.8		520	8.30	206	0.060	0.800	0.800	0.003
	17	15 0015	12.9	8.4		520	8.20	208	0.080	0.900	0.800	0.005
	17	15 0022	11.6	6.0		530	7.80	206	0.180	0.900	0.800	0.009
	17	15 0029	8.7	2.3		535	7.70	214	0.620	1.400	0.530	0.018
73/10/12	14	15 0000	19.5	8.6	78	403	8.50	181	0.080	1.500	0.030	0.009
	14	15 0015	17.6	1.8		402	7.70	188	0.270	1.200	0.020	0.026
	14	15 0027	10.2	0.0		437	7.10	272	2.230	9.000	0.040	0.566

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	17	15 0000	0.018	13.3
	17	15 0006	0.030	
	17	15 0015	0.035	
	17	15 0022	0.033	
	17	15 0029	0.054	
73/10/12	14	15 0000	0.033	7.4
	14	15 0015	0.030	
	14	15 0027	0.620	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/04/08

184581 and 1841A1
41 32 45.0 085 24 44.0 4
DALLAS LK-WRESTLER LK CONNECTION
18 7.5 OLIVER LAKE
I/DALLAS LAKE
BANK SAMPLE TAKE FROM E BANK
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 05		0.390	1.600	0.016	0.005K	0.030
73/07/14	10 15		0.014	1.760	0.065	0.005	0.015
73/08/12	13 25		0.010K	1.000	0.026	0.010	0.015
73/09/08	09 30		0.010K	0.690	0.013	0.005K	0.010
73/10/06			0.010K	1.260	0.020	0.005K	0.020
73/11/09	12 00		0.040	1.950	0.520	0.036	0.045
73/12/08	09 00		0.076	1.300	0.276	0.008	0.075
74/01/22			0.300	1.200	0.240	0.010	0.055
74/02/09	11 00		1.200	1.000	0.185	0.010	0.050
74/02/23	10 00		1.600	3.400	0.240	0.020	0.050
74/03/09	12 45		1.520	2.150	0.150	0.020	0.090
74/03/23	11 00		1.340	2.000	0.075	0.020	0.070
74/04/13	09 30		1.120	2.900	0.115	0.015	0.030
74/05/11	15 10		0.880	1.000	0.200	0.055	0.115

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/04/08

1842A1 and 1841B1
41 32 12.0 085 23 50.0 4
WESTLER-WITMER LAKE CONNECTION
18 7.5 OLIVER LAKE
O/WHITMER LAKE
700 S RD BRDG SW OF WEBERS LANDING
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 40		0.330	1.900	0.056	0.007	0.040
73/07/14	12 10		0.017	1.260	0.024	0.006	0.015
73/08/12	12 10		0.010K	1.050	0.016	0.011	0.020
73/09/08	09 35		0.010K	0.940	0.022	0.005K	0.020
73/10/06			0.010K	2.100	0.032	0.005K	0.030
73/11/09	12 15		0.028	1.250	0.310	0.048	0.090
73/12/08	09 00		0.088	1.600	0.288	0.016	0.080
74/01/09			0.630	1.200	0.232	0.016	0.075
74/02/09	11 00		1.760	1.100	0.110	0.020	0.075
74/02/23	10 10		1.180	0.900	0.090	0.010	0.045
74/03/09	13 00		1.280	1.200	0.185	0.040	0.100
74/03/23	11 20		1.340	1.100	0.085	0.025	0.055
74/04/13	09 30		1.200	1.550	0.027	0.012	0.012
74/05/11	15 00		0.830	0.950	0.155	0.035	0.110

K VALUE KNOWN TO BE
LESS THAN INDICATED